STUDIES IN INFORMATION SYSTEMS

Procedures for Analysis of Information System Effectiveness -- A Working Manual

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13 ABSTRACT

This manual is a working document to assist in evaluating a variety of information processing activities. A generalized procedure is outlined to assess the capability of an information system to meet functional, user-oriented requirements. The authors propose a composite overview which will be the basis of a systematic approach to information system evaluation. Stress is placed upon identification of tangible benefits and measures of effectiveness. Refinement and standardization of the approach are anticipated on the basis of experience in applying its phases to systems operating under differing circumstances.

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Foreword

This manual is a working document based upon experiences of a number of people in evaluating a variety of information processing activities. The authors propose a composite overview which will be the basis of a systematic approach to information system evaluation. The procedures outlined herein are intended to be applied to several operational systems and the results analyzed to determine the value and cost associated with each step under differing circumstances. Refinement of the approach and a revised manual are anticipated after experience is gained from these evaluation studies.

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I. Introduction

For years computers and computer-based information systems have been sold on the strength of intangible, and often illusory, benefits. Prevailing economic conditions coupled with common underestimates of resource and time requirements have engendered recently an era of greater discrimination by managers and computer users. Formation of profit or cost centers for information processing services, application of capital authorization criteria for system development, and closer scrutiny of operating expenses for computing and information processing have resulted. Attempts to evaluate the effectiveness of systems have been thwarted by difficulty in identifying and quantifying tangible benefits resulting from operation of the system. This stems from lack of definition of system objectives in functional terms, of standardization in applying data processing techniques, and of formalization in methods for evaluation. The latter area is of particular interest today, because current practice becomes relatively less adequate as information systems deal increasingly with more complex, integrated functions. This manual will assume the following general description:

- Information System -- A set of interrelated rules and procedures for processing data into information in order to get or control action.

A substantial amount of empirical study is directed toward performance measurement of computer systems. Emphasis therein is placed on speed of computer operations, throughput of the computer, capacity utilization of processing components, and response time to the user. These are useful in comparing alternative methods of achieving given results or in assuring timeliness of output. Computer specialists, such as system analysts and programmers, are likely to appreciate and strive for improved performance in these areas.[1, 4, 5, 8]

The customer of information processing services, however, is more concerned with quality of system output. Quality is related

to accuracy of input, reliability of processing, and appropriateness of output: that is, insuring adequacy, but not excessive, reports according to need and the situation. The degree of detail in output and frequency of reporting varies with, among other things, the level of activity being served. General classifications of these levels are shown in Table I-1. Various forms of management decision-making are required by these levels of activity.[7] Decision-oriented systems normally include attributes of several activity levels, especially those involving tactical and operational aspects. The benefit parameters of computer-based systems must be related to these functional activity descriptions in order to assess the effect of information on the behavior of the customer, or system user. This latter area is of major concern because it relates to impact on management decision-making and short range planning rather than the narrower horizon of computer performance in gathering and manipulating data. This emphasis also offers greater challenge to analyze information system effectiveness in light of dynamically changing personal and organizational requirements for information.

In this sense, information is defined as a response to user demand that is timed and structured to be useful in decision-making or control tasks (as opposed to an accumulation of facts, or data). This suggests a need to isolate the results of decisions from associated input to decision-makers in order to determine the quality of information provided by the system.[2, 3, 6]

Messages which convey information. have the following attributes relative to the problem at hand:

- Timeliness
- Accuracy
- Relevancy
- Sufficiency
- Conciseness
- Discovery

Table I-1

Activity Levels

Title	Description	Information System Implication
Strategic	Planning and policy considerations related to future time periods or resources. Goal-oriented and horizon extends beyond normal information system support coverage. Decisions are non-programmed and require extensive deliberation.	The information system must provide a meaningful data base for forecasting. Very little objective data bearing directly on area of study is available.
Tactical	Planning and selection of alternative courses of action for several existing operating units and/or proximate time periods. Considers scheduling and utilization of resources in current accounting period. Decisions are non-programmed unless constrained by policy or short term plans.	Summary and analysis of performance data which must support functional management needs.
Operational	Immediate supervision, monitoring or control of resources applied to ongoing activity. Concerns current cycle of operations (not arbitrary time periods) and programmed decisions.	Requires feedback and continual processing to provide support within the operation time cycle.
Execution	Performance of assigned functional tasks by applying available resources. Concerns established procedures necessary to accomplish an assignment or process.	Reports of completed tasks become basic input to the information system. Includes record-keeping and conditioned reactions to transactions.

The latter is particularly important because it assures that the recipient learns something of which he was unaware before receiving the message.

The results of studying and developing evaluation procedures for existing information systems provide insight about assessing the effectiveness of complex, multivariable situations. Normally an information system will include one or more of the processing characteristics outlined in Table I-2. Study should indicate the blend of characteristics existing or planned which would satisfy identified functions and perform specific tasks. It should then be possible to extrapolate those results to forecast the demand for information services and to propose the most effective and economical means of providing same.

A commonly recognized fault limiting the success of information systems is the lack of customer or user participation in the definition of system requirements. These should be stated in a formal document oriented to terminology and functions of the operational group to be served. The customer should provide about half of the effort in the analysis and feasibility phases which should culminate in a customer approved report on requirements which includes: (See Appendix B for detail.)

- Mission or problem statement
- System objectives
- Output and report definition
- Input description
- File definition
- Controls and tests
- Schedule constraints
- Cost analysis
- Project plan

It is assumed that the accuracy of the cost analysis and the effectiveness of the project plan are assessed best during and immediately after the development of the system. This set of user requirements then becomes the primary source for evaluating effectiveness of information system operation.[9, 10, 11]

Table I-2

Processing Characteristics

Planning	Models to project and forecast based on historical trends and estimates of the future. Normally requires a representative sample data base rather than live operational data. Interactive mode of operation is highly desirable.
Management	Analysis of the utilization of resources by functional managers. Requires complete actual data. Mode of operation is usually batch-oriented unless decisions are related to short cycle period.
Communication	Transmission of messages among remote sites. Requires proper distribution of input without interpretation or alteration of content. Normally requires on-line processing with store and forward capability.
Data Base	Collection of data and storing in computer-based files for future access to content or facts. Requires frequent, if not continuous, input of data from a variety of sources. Normally requires on-line inquiry mode for effective delivery of output.
Monitoring	Gathering and analysis of data from a specific process or operation on a continual basis. Normally involves on-line capturing of digital and/or analog data and immediate feedback to control the operation.
Reference	Retrieval of documents or references thereto, often based on material stored in microform, technical papers, and other media not computer-compatible. Initial reference is often accomplished by on-line computer operation. Delivery of the desired input is normally an off-line, batch oriented library process.
Scientific	Algorithm oriented processing related to calculation for analysis or estimation of operational data. Includes statistical and engineering calculation. Processing is normally done in batch mode but input may be collected on-line or aggregated for subsequent processing.

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II. Preparation for an Evaluation Study

Purpose of Study

For an evaluation study to be successful, it is necessary that management be willing to act upon recommendations of the study finding. Also, it should be likely that resources to effect necessary changes will be available to implement any decisions resulting from the evaluation.[1, 3] The persons authorizing the study and receiving the findings must have purview over the system operation and the functional activities served by the system. Motivation to assess system effectiveness generally stems from:

- -- Need to diagnose problems in an existing system (including cost of operation).
- -- Dissatisfaction expressed by users of a system.
- -- Proposal to modify or revise a system.
- -- Plans to implement a new system.
- -- Scheduled event for audit or evaluation.

In any case, the objectives of the evaluation study need to be carefully delineated in order to assure that the analysis achieves management purposes.

Evaluation should consider the expected life of the system but, unlike some life cycle analysis, the time value of costs and benefits must be considered at appropriate rates of return.[19] Particular attention should be given to identifying possible unintended benefits or side effects rather than concentrating on initial statements of objectives. A number of other considerations are important to the success of such a study, namely:

- -- User involvement in the evaluation.
- -- Written charge to the study team to clarify purpose and organizational relationships.
- -- Authority from management with purview over full scope of the systems.
- -- Timing the study for representative periods of activity.

-- Review of documentation, but validate its accuracy and completeness by use other sources.

-- Review of prior evaluation or audit reports (By whom, findings, resulting action?)

-- Avoid the study if it is motivated by coercion or if management is indifferent.

-- Phrase reports in the language of management, not system terminology.

-- Design the system initially to provide performance data as a by-product of normal system operation.

Above all, the need for evaluation should be apparent and follow-up action possible or the study is almost surely due for the archives.

Organization of the Study Team

Because of the diverse interests and broad implications of most information systems, evaluation should be conducted by a team. Representatives of major functional activities served by the system(s) and practitioners in data processing should be the principal constituents. Consultants often supply objectivity and breadth of experience to the study. Depending upon study emphasis and objectives, it may be desirable to include an accountant, an organizational behaviorist, or other specialists on the team. The role of the system designer, development contractor, and computer operations should be minimized to that of sources of evidence rather than team members. In general, four or five people would be assigned responsibility to conduct the study.[3, 5, 41]

Leadership of the evaluation team should come from a consultant or from an operational manager whose activities are directly affected by the system. In either case, the individual must have objectivity and also have sufficient influence to initiate short term improvements or changes during the study that are proven necessary. A secretary or coordinator should be appointed to act as a repository for collected data and interviews, to record notes and decisions, and to prepare and disseminate reports. The study leader normally arranges schedules and monitors

progress of the study. It is important for all members of the team to establish and maintain rapport with functional management requirements throughout the study.[41, 44]

Study Plan

Once the objective, scope, and team membership have been defined and published, it is possible to develop a study plan. The major tasks to be completed in the study plan are discussed briefly.[32, 41, 47]

Task 1: Orientation. The first task is to indoctrinate both management and the study team. Higher levels of management must be oriented to the importance of system users, to the current state of the art in computing, and to formal description of their functional responsibilities. The study team needs to consider the boundaries of the system, policy constraints, and assumptions necessary to define the problems and issues before them. Background of system requirements, related prior studies, and existing performance standards also help describe the environment in which the evaluation will be conducted. Particular attention should be given to identification of existing base lines for performance and measures of effectiveness.[18, 28, 40] If the latter are not already established, they must be developed during Task 6.

Task 2: Selection of phases. The generalized procedure in part III of this manual outlines a number of potential phases for the study. Each phase must be considered to determine its relevancy to the authorized study. The objectives of the study and likely availability of staff time and resources will suggest the degree of detail for the study. For each possible phase, selection must be made according to the Activity Levels (Table I-1) and Processing Characteristics (Table I-2) associated with the system(s) to be assessed.

Task 3: Selection of methods. For each phase that is deemed appropriate for the study, there can be a variety of methods

Table II-1

Methods of Investigation

Source or Method	Comments	Cost Factors
Documentation: Available sources of historical data		
System requirements and specifications; job descriptions and procedures.	Status frequently not current; mostly qualitative.	Inexpensive source
Accounting and operational records or statistics.	Quantitative and categorized; detail often insufficient.	Inexpensive source
Standards of performance and processing	Methods have often changed.	Inexpensive if available
Input and report document formats.	Static picture of the nature of content; no idea of effect.	Analysis cost is low to moderate
Measurement: Quantitative variables gathered by study team.		
Observation	Work sampling;[21] methods and procedure analysis; [17, 38, 43, 50] matrix or graphical description of data flow.[11, 22, 23, 35, 42, 48, 49]	Low to moderate cost; mostly analyst time
Monitoring	Hardware and/or software recording of activity; byproduct of operation.	Cost of monitoring tool and analysis is moderate to high
Simulation	Model of activity; statistical analysis of sensitivity and performance; allows estimation of the effect of proposed changes.[20]	High development and computer running costs

Table II-1
(Continued)

Views: Subjective and qualitative variables with user participation

Interview (I, G)	Patterned, or structured	Planned in advance; minimum interviewer bias; forced coverage; conducive to comparison and correlation.	1/2 to 1-1/2 hours per interviewee
	Unstructured	Open-ended depth study; dependent on skill of interviewer; substantial post-review and analysis by interviewer(s).	Half day per interviewee (perhaps several sittings)
Survey (I, G)	Questionnaire	Conducive to comparison and aggregation; staff input likely: need interpretation of response sample; non-response bias an issue.	Low cost for respondent
Consensus (G)	Conference	Transcription and analysis effort large; scheduling and objectivity of interviewees give problems.	User and analyst time high
	Delphi	Dependent on skill and knowledge of administration; systematic consideration of subjective opinions. 2, 6, 9, 25	Large elapsed time and administrative cost.
Gaming (I, G)	Management	Substantial work in developing material; good to describe situation reactions and to involve personnel. 7, 12, 33, 45, 51	High investment; validation and subject time costly.
	In-basket	Allows estimation of alternative effects and observation of individual habits and performance. 14, 15, 24	High investment; validation and subject time costly.

I - Individual views G - Group views

employed. In some steps, the comparison of costs among alternatives can be nil or greater. Table II-1 summarizes the most commonly used methods and issues related to them. Cost considerations may eliminate a phase from the study or suggest a more limited estimate of the situation. The references at the end of this section refer briefly to basic concepts of system analysis. (See Table II-1). Further, they provide some overview of the evaluation process and examples of gaming and Delphi techniques. Both the latter can be modified to assist analysis of highly subjective areas and to minimize the bias resulting from orally expressed opinions. Each requires special skills to develop and conduct investigation by the method.

Particular attention should be given to getting candid responses in the various methods. Careful preparation of managers for interviews may promote answers which reflect how the system should work rather than how it does. Impromptu sessions tend to elicit normal reactions and measure personal understanding rather than encouraging staff briefings which reflect intent or composite views.

Task 4: Establishment of schedule and priorities. The cost/benefit estimates for each phase will suggest relative priorities.[27] The number of personnel assigned to the study team and the selected methods are the basis for developing a pattern of investigation and analysis. Restrictions on time to complete the evaluation will impact this pattern and, perhaps, will necessitate revision of selected phases or methods. A study will normally be 4-7 weeks in duration. Basic studies may require only a week, but major systems with ill-defined objectives may necessitate six months or more of elapsed time.[3, 5]

Task 5: Estimation of resource needs. Often the size of the study team and authorized expenses are fixed. Thus, the major resource to be identified is the demand for management

and system user time. Sometimes either the complexity or volume of study effort will require supplementary team assignments. The proportion and timing of participation by each team member should be allocated to the proposed schedule. Technical and support assistance, particularly that related to selected methods, should also be included.

Task 6: Affirmation by management. It is important to reinforce management interest and to ensure their understanding of the study. The objectives, time schedule, format, and resource needs should be presented for review. Particular attention must be given to the contacts and interactions expected between the study team and operational management. Groundwork is laid to overcome possible resistance to change and anticipated personal conflicts. Agreement in advance of the study proper identifies the groups that will be involved, approves the study plan, and reaffirms the study team authority.

Task 7: Conduct of phases. The conduct of each selected phase is discussed in part III. Instruments for collecting data are designed; treatment of data is planned, and criteria for analysis are designated. Data are gathered, aggregated and stored using the various methods and sources. The study team analyzes input and debriefing sessions are held to keep management and team personnel aware of progress and interim findings. The results of each phase are documented as exhibits to the final report.

Task 8: Dissemination of findings. Principal results of the study should be reported to the affected management orally. This may be done by meetings, talks, or highly visual presentations. A written follow-up should be presented by a formal report, a series of memoranda, or other hard copy media. The content should be expressed in management or user vernacular and limited to important issues requiring attention. Exhibits and background material should be maintained on file

by the study team.[5, 41, 47] The written report should contain:

-- General information
    - Purpose and goals of evaluation
    - Team composition
    - Methods used
    - Timing
    - Areas assessed
    - Summary of meetings and oral presentations
-- Summary of findings
    - Significant accomplishments
    - Adverse performance areas
    - Recommended action(s)
-- Management rebuttal or comment
-- Study team rejoinder

Recurring Audits

Periodic evaluations should be conducted on the basis of the expected system life, which is rarely longer than 3-5 years. Each study will determine the current effectiveness of the system and predict its capability to handle expected growth and change. In addition, the recurring audits will measure results of implementing recommended action which stems from prior evaluation findings[36] and will appraise the system against alternative ways to support the same functional requirements.

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III. Generalized Evaluation Procedure

The evaluation of information systems involves six major areas of study and analysis. The first three phases (A1-3) describe the organizational functions performed at the various levels of activity, the remaining three phases (B1-3) relate to identification and description of the information system(s) which serve these functions. An outline of the procedure follows:

A. Characterize the function served

1. Define Organization Mission
2. Describe Functional Performance
3. Identify Alternative Courses of Action

B. Assess the current state of the information system

1. Define the system(s) characteristics
2. Audit economics of the information system
3. Measure information system activity

Each of these areas must be assessed as to its importance in a given evaluation study. Thus, the actual study plan must be tailored from the generalized procedures in order to achieve study objectives. The contribution of each area must be considered in light of the kind of system under study, the level(s) of activity involved, and the methods of analysis to be employed. The Purpose amplifies the contribution of this step to an evaluation study. Circumstances under which the step would be appropriate are indicated under Selection. Possible methods of investigation and suggestions about Conduct of each facet of the study are also discussed at some length. Information for further study, charts and reports produced in the step are described briefly in the Result section.

A. Characterize the Function Served

1. Define Organization Mission. This is a clear statement of the mission and expected life of functions performed by the

customer organization to accomplish the mission. The nature of information services used and interactions with other groups in handling data are important parts of the description. Particular attention should be given to identifying environmental influences on the functions performed. It is particularly important to note changes in assumptions or requirements which would obsolete documentation about a pertinent system requirement.

a. Major Functions

• Purpose: To explore the character and expected life of functions performed by the customer organization. Changes and trends in the functions performed should be carefully noted, as these may not be reflected in the documentation on policy and procedures.

• Selection:

Characteristics

Planning	Relevant and necessar
Management	Relevant and necessary
Communication	Not relevant
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Possible for tactical activity
Scientific	Relevant in some situations

Activity Levels -- Strategic and tactical

Methods -- Structured or depth interview; group consensus

• Conduct: The evaluation team meets upper management for an overall orientation to the organization and its goals. Major functional components of the organization and the corresponding management personnel are identified. Members of the evaluation team then conduct interviews with managers at the tactical level, soliciting individual views

on the nature of each function and its expected life. A structured interview should require from about half an hour per manager to a maximum duration of one hour and a half. An open-ended depth interview would generally require at least half a day, preferably being conducted in several sittings. If functions are not well defined or established, it may be necessary to resolve subjective opinions using more elaborate methods to develop a consensus.

The evaluation team should meet at frequent intervals during this interview phase to cross-check the functions served and their interrelationships. Inconsistencies should be resolved by going back to the managers for clarification. If key subfunctions are recognized at this time, the evaluation team may then decide to include subordinate managers in the interview procedure. Schedules should be modified accordingly.

Following is a checklist of questions to guide the evaluation in conducting the interview:

(1) What are the major functions in each area of responsibility?

(2) How have these changed over the past several years? (Use time frame of current information systems)

(3) What trends are anticipated in performance of these functions?

(4) What is the expected life of each function within the organization?

- Result: The evaluation team should reach general agreement on the major functions performed by the organization so that the functional components of an information flow diagram can be sketched as input to later steps.

b. Information Support Required or Provided

- Purpose: To examine the general nature of information

support required or provided in the course of performing major functions.

- Selection:

  Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Not relevant
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Advisable for tactical activity
Scientific	Often relevant and advisable

  Activity Levels -- Strategic and tactical

  Methods -- Structured interview, questionnaire, or observation

- Conduct: If possible, this should be investigated during the process of defining user functions. The structured interview is preferred for this phase, with the following checklist of questions to guide the interviewer:

  (1) Describe the activities which are dependent on information service support to perform each function.

  (2) Describe the activities which involve providing information service support to other group(s).

  (3) Describe the nature of each such information service.

    (a) Normal use of the service.
    (b) Special uses of the service. Under what conditions?
    (c) Schedule of usage and correspondence to events.
    (d) Consequences of failure.
    (e) Required for how long?

"In-basket" analysis is often useful in determining interaction of information services. This entails observation of the content of material received and disseminated

by a manager in order to determine the frequency and nature of information from and provided to other groups. Questionnaires may be utilized to conserve time and/or expense.

• Result: The evaluation team should reach general agreement on the information used in conjunction with performance of functions. Major information flows should be described in matrix or network format.

c. Environmental Influences

• Purpose: To explore environmental influences on groups within the organization; especially those restrictions which limit effective use of information support services.

• Selection:

Characteristic:

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Sometimes relevant
Data Base	Frequently relevant
Reference	Frequently relevant
Monitoring	Relevant at tactical level
Scientific	Frequently relevant

Activity Levels -- Strategic, tactical and operational

Methods -- Delphi study, questionnaire, depth interview

• Conduct: External influences should be elicited during the process of defining user functions and information support. Other methods involve substantial expense to get more than cursory views. This phase deals with future events and its speculative nature frequently necessitates a

Delphi study. Since there is little precedent for determining effects of environmental factors, an open-ended depth interview of specialists in several management and staff areas is appropriate. A checklist of questions follows:

(1) What external problems or restrictions limit effective use of information and information systems?

Technology
Resources Available
Experience and Capability of Personnel
Market and Competition
Management Policy
Political and Governmental Issues
Economic Factors (GNP, employment, productivity, price and wages)
Demographic and Social Factors
Public Interest and Acceptance

(2) In reference to the above factors, what changes or trends have altered use of information and information systems in the recent past?

(3) What changes or trends are anticipated in the foreseeable future?

(4) Alternatively, does use of information and/or information systems exert any positive or negative influence on these factors?

The evaluation team may also decide to seek expert opinion from outside the organization to help weigh the affect of environmental factors. This is especially important in resolving controversial issues raised in this step.

A questionnaire will generally be the most cost-effective way to seek comprehensive opinions; although a full Delphi study may be warranted in instances where environmental factors play an unusually significant role. Questions should follow the general interview outline, but should be tailored to emphasize coverage of important areas revealed in earlier interviews.

• Result: This phase should produce a clear statement of environmental factors and their possible effects on information usage.

2. Describe Functional Performance. The major tasks and sequences to perform functions are reviewed and developed into a scenario of personnel interacting in activities which require use of information services, identifying the various classifications of activity levels. Options and possible events related to functional performance are recorded. The nature of data flow and the interactions among people are reviewed. Often it will be necessary to assimilate subjective opinions about desired or actual performance. Operational gaming can be developed to observe individual behavior toward information when confronted with functional tasks and to instruct in more effective methods of information use. Job descriptions and procedures manuals are considered to the degree that they prove accurate and current to actual practice.

a. Major Tasks and Sequence

• Purpose: To describe major tasks and activity sequences for each function. These may be derived from those functions identified in earlier phases of the study.

• Selection:

Characteristics

Planning	Rarely relevant
Management	Relevant and necessary
Communication	Relevant for execution and operational levels
Data Base	Relevant and necessary
Monitoring	Relevant; normally documented
Reference	Sometimes relevant
Scientific	Relevant; normally documented

Activity Levels -- Tactical, operational and execution

Methods -- System documentation, interviews

• Conduct: Any existing documentation on job descriptions and standard procedures for performing repeated functions should be collected and reviewed by the evaluation team. Since it frequently does not reflect actual practice, it is also advisable to question informally managers as to the relevance and accuracy of this documentation.

If there are strong indications that the documentation does in fact deviate significantly from actual practice, then interviews should be conducted in depth. Conversely, if the documentation is felt to be relevant and accurate, then the interview can be conducted as a verbal review of the documentation, clarifying minor deviations from and implications of the written procedures.

Following is a checklist of questions to guide the evaluator in conducting the interview:

(1) Describe step by step the tasks which are performed to support previously identified functions.

(2) What events affect performance or sequence of these tasks?

(3) What options are possible in performing these tasks?

• Result: A diagram or flow-chart of the tasks performed in sequence should be developed to accompany the verbal descriptions elicited during interviews. External events and internal options which affect task sequence should be depicted as branch points on the diagram.

b. Scenario of Information Use

• Purpose: To review major tasks and procedures in light of requirements for information support. A scenario

of information use in performing tasks is developed.

At this point, we are still dealing conceptually with "information support services" rather than with particular "information systems". This is true because the user may require several related reports produced by different systems in order to perform effectively a function. The user may in fact be totally ignorant of which system is generating a specific output. Analysis should cover not only the current use of information services, but potential use as well.

- Selection:

  Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Often relevant and advisable
Data Base	Often relevant and advisable
Monitoring	Relevant and necessary for operational, possibly tactical
Reference	Often relevant and advisable
Scientific	Relevant and necessary

  Activity Levels -- Strategic, tactical and operational

  Methods -- Open-ended depth interview; gaming, Delphi technique

- Conduct: Existing documentation is not apt to be helpful for this approach, and heavier reliance is therefore placed on an open-ended depth interview. A checklist of questions follows:

  (1) What specific use(s) are made of information support services in performing each functional task?

  (2) What additional use(s) could be made of each information service in performing each task if minor changes were made to the service?

(3) Are there uses for which an information service was intended, but for which the service is unsuitable or ineffective? What are the problems?

(4) Are there uses for which the information service was not intended, but for which the service proves useful in performing assigned tasks? What procedural changes, if any, were made to take unforeseen advantage of the service?

(5) What specific effects would failure of a supporting information service have on each task? Are there backup sources of information? In what ways are these backup sources inferior to the primary information service?

(6) What options are available in performing assigned tasks? What are the possible outcomes of each task?

(7) What alternative courses of action are influenced by available information support?

During analysis of interviews, the evaluation team is apt to discover differences of opinion concerning the desired or actual use of information support services. Such differences may occur because of the diversity of functions performed by user groups or because of the varying breadth of perspective associated with each management decision-making level.

Depending on the criticality of the area in which a difference of opinion might occur and on the degree of polarity of user views, the evaluation team may decide to utilize more expensive operational gaming techniques and/or Delphi techniques to attempt resolution of subjective opinions. Gaming techniques are generally more appropriate to assess personnel reactions and behavior under simulated situations. Approaches assist in more consistent description of prescribed procedures for performing tasks.

• Result: At the end of this step, an overall functional diagram of the organization should be developed which depicts major functions (primarily physical processes such as production) and major information networks. The

diagram should be accompanied by a written scenario of information use by each functional group. Both the diagram and the scenario description serve as a reference point for subsequent evaluation steps which reexamine information service usage at a finer level of detail.

c. Forms of Data and Interactions Involved

• Purpose: To examine the nature of data supplied by and provided to each function to support defined tasks. Interactions between groups in supplying and using information are an important part of the description. The objective of this analysis is to be able to trace the flow of each data element from its source to its ultimate use(s) in performing functional tasks.

• Selection:

Characteristics

Planning	Sometimes relevant
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary
Reference	Sometimes relevant
Monitoring	Relevant and necessary
Scientific	Relevant and advisable

Levels -- Strategic, tactical, operational, execution

Method -- Observation, interview, analysis of forms

• Conduct: Samples of the paperwork involved in collecting, processing and interpreting data should serve as the basis for supplementary observation or structured interviews. Examples of such paperwork are data preparation forms, computer printouts, hard-copy of on-line transactions, input media and report formats.

If non-paper media (CRT, voice etc.) are used for collection and retrieval of data, then samples should be transferred to a hard copy medium (picture of CRT or script reduction of voice). This will facilitate planning of the interviews to assess all such materials jointly by the evaluation team and affected managers. As a minimum, members of the evaluation team should observe data collection and retrieval procedures first hand in order to prepare notes as the basis for interviews.

In the process of analyzing the forms, printouts, etc. in detail and conducting interviews, the following should be considered:

(1) Describe identify briefly the data in functional terms.

(2) Identify groups required to collect, analyze, search, interpret and/or summarize data for functions being reviewed.

(3) Identify groups which request the group under study to collect, analyze, search, interpret or summarize the data for their use.

(4) Describe groups which interact during effective use of data.

Questions 2 and 3 serve a valuable purpose in showing interrelationships among different groups. Omissions, discrepancies and conflicts can generally be resolved by tracing data flow from functional tasks back to the source.

- Result: The tangible output of this activity is a set of matrices depicting the flow of data from the source, through intermediate levels of activity, to the business function(s) served. Such matrix models facilitate analysis of the alternate paths of data from source to functions. Specifically, the matrix may reveal (a) data which is being collected but not used or (b) data which can arrive at a business function through several, possibly redundant, paths.

3. Identify Alternative Courses of Action. For decision-making and planning activity support, it will be necessary to identify the major decisions to be made and to describe possible alternative courses of action in terms of the functional operations served. Then the information required to make a choice among alternatives must be analyzed. Study of the decisions involved must assess for each alternative:

a. Payoffs and consequences if selected.
b. Risk and utility of related course of action.
c. Probabilities of selection and success thereafter.

This is a particularly difficult and time consuming step. It involves technical preparation in decision analysis and skill in interpreting empirical utility estimates on the part of the evaluation team. The system user must also exhibit substantital patience and cooperation to derive full understanding and benefit.

a. Description of Alternatives in Functional Terms

• Purpose: To identify the kinds of decisions made and activities controlled as part of task performance. For each such decision or activity, the available alternatives are spelled out and described in operational terms.

• Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Data Base	Relevant and advisable
Communication	Rarely applicable
Monitoring	Relevant and necessary
Reference	Relevant and advisable
Scientific	Sometimes relevant

Activity Levels: Strategic, tactical and operational

Method: Interview, analysis of documentation

• Conduct: The interview should be conducted within the context of the just developed scenario of information use. Questions 6 and 7 of the previous step are especially pertinent and should serve as the basis for this interview. Documentation may describe the programmed decisions adequately for operational systems. In this phase, the study team enumerates a comprehensive list of the viable alternatives for each situation involving decisions about or control over execution of tasks. This should be done in terminology characteristic to the function under study. A checklist of questions follows:

(1) What are the major kinds of decisions made or activities controlled? Relate these to task performance.

(2) What viable options and alternatives are available for each decision or activity?

(3) What possible events and parameters influence selection of an option or alternative course of action?

• Result: A list of alternative courses of action for each decision or point of control related to specific tasks Each should be discussed in terms of the variables which influence selection of the alternative.

b. Information Required

• Purpose: To describe the specific information required to select each identified alternative.

• Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Normally relevant
Data Base	Normally relevant
Monitoring	Normally well-defined

Reference	Sometimes relevant; expensive
Scientific	Sometimes relevant

Activity Levels: Strategic, tactical, operational

Method: Interview, observation, gaming

• Conduct: The interviews should be conducted as an item by item review of alternatives. Determination of all the information required to choose an alternative may take considerable prodding and skillful questioning on the part of the interviewer. Situational gaming, in the form of posing hypothetical decision situations to the manager, and observing reactions, is often useful in discovering and verifying what information is actually needed. Actual performance can also be observed by "in basket" or activity sampling techniques. The care and patience which must be exercised in this procedure make the activity time-consuming and therefore expensive.

The default option, appropriate when insufficient information is available, is an important part of this analysis. The default option takes the form of maintaining the status quo or postponing positive action until necessary information is available. Such passive alternatives should be considered as viable options for the decision along with all positive actions.

Following is a checklist of questions to guide the interviewer:

(1) What information is necessary before selecting each alternative?

(2) What is the role of information in increasing or decreasing the probability of success for each alternative?

(3) Would more or less detailed, accurate, timely, relevant, or reliable information alter your decision? What are the upper and lower limits for each factor which would leave the decision unaltered?

(4) At what point is decision or control action taken no matter what additional information is received?

• Result: Facts elicited in this investigation should be summarized in tabular form, clearly depicting the alternatives available for each decision and the information requirements for each. Diagrams such as decision trees showing sequences of decisions and all possible paths for alternatives, are useful outputs at this stage. Subsequent steps cover identification and further definition of the branches and options identified.

c. Goals and Consequences of Alternatives

• Purpose: To identify all possible outcomes of each alternative in terms of both the effects and consequences that may result if the alternative is selected and implemented.

• Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Rarely applicable
Data Base	Sometimes relevant
Monitoring	Desirable for constrained area
Reference	Rarely applicable; expensive
Scientific	Sometimes relevant and advisable

Activity Levels: Strategic, tactical and operational

Method: Interview, Delphi techniques

• Conduct: The interview in this phase builds upon and amplifies the results of the previous two steps. Again, this step is time-consuming and patience is needed to get accurate and comprehensive results. Delphi may be required to predict possible consequences of important

decisions for which the organization has little or no precedent or where subjective estimates vary widely. Tactical managers within the organization and, possibly, outside experts should be included in such a Delphi study.

Following is a checklist of questions to guide the evaluator during the interview. These same questions can serve as the basis for a Delphi study, however they should be directed to specific issues and situations for this purpose.

(1) What goal(s) is associated with each alternative under consideration?

(2) What other effects or consequences may result if each alternative is attained? How are these possibilities affected by events over which you have no control?

(3) What is the source of determining the likely outcome(s) of applying an alternative? (If subjective, a Delphi study is suggested.)

• Result: The findings of this phase should be incorporated with the results of the previous steps into the decision tree diagrams which were roughly stated in step A3b. They should indicate all feasible outcomes from selection of each possible course of action. The decision tree should indicate the sequence of decisions involved in performing a task. Branch points or nodes should clearly differentiate management alternatives from chance or external influences.

B. Assess the Current State of the Information System

1. Define the System Characteristics

The goals and functions of each system affecting an operational activity area should be reviewed, noting carefully the changes in purpose or benefits derived in comparison to earlier documentation. A scenario should be developed to describe activities of various groups interacting with and using the system. Parameters to measure the system effects on its users and criteria of satisfactory performance should be developed. This may again entail the transformation of subjective opinions into tangible measures.

The degree to which expected benefits are realized will depend greatly on the user role in development, project team discipline, and realistic planning. The evaluation team should not be surprised that serendipity often provides unintended benefits or shifts in utilization which drastically alter the worth or objectives of an existing system.

As an important adjunct to this evaluation phase, the adequacy of computer system performance should be assessed in light of the enhancement or detraction from attaining system goals. The computing environment including standards, controls, security, and personnel qualifications, is also a strong influence.

a. System Goals and Functions Served

- Purpose: To review system goals and relate the system to the organizational functions served. Emphasis is placed on distinguishing both intended goals and the actual current use to which the system is being put.

- Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary

Reference	Relevant and necessary
Monitor	Relevant and necessary
Scientific	Relevant and necessary

Activity Levels -- Strategic, tactical, operational and execution

Methods -- System documentation, interviews

• Conduct: Existing system documentation should be examined to determine the stated goals and the functions each was intended to serve. The evaluation team should assess the accuracy and currency of system documentation. Stated goals are very likely to have been supplanted by new ones, either formally or informally.

Information support services should be reviewed in detail (part A2) and the role of specific systems in providing each service should be clearly delineated. The interdependencies among systems necessary to provide effective service should also be noted at this point.

The interview is a useful technique for assessing the changes in purpose of or benefits expected from a system in comparison to earlier documentation. Following is a checklist of questions to guide the interviewer:

(1) What information system(s) provide necessary support services?

(2) What is the current status of each system and how does this affect your assessment?

- (a) Newly installed?
- (b) Fully operational? For how long?
- (c) Under revision?

(3) What technical, economic and operational benefits?

- (a) Were expected from the system?
- (b) Have been realized by the system?
- (c) Are still anticipated for the system?

(4) What problems limit the effectiveness of each system?

(5) What is the expected useful life of the system?

(a) Could system modifications extend or shrink the useful life? Specify.
(b) Could environmental changes extend or shrink the useful life? Specify.

(6) What growth in emphasis, use, transactions, and/or files can be anticipated?

• Result: This phase of the analysis should result in a basic understanding of the relationship between functional requirements and information systems. All changes in functional requirements, evolution in use, and modifications to systems should be explicitly documented. Finally, systems should be assessed according to their ability to fulfill current and future needs for information support.

b. Scenario of System Use

• Purpose: To develop a written description of actual interaction among user groups and the system. This will include operational description of system use, effects of the system on users, satisfaction of users, and impact of the output on decisions or control of activity.

• Selection

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Relevant, usually simple pattern
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Usually implicit in documentation
Scientific	Relevant and desirable

Activity Levels -- Strategic, tactical, operational, execution

Method -- Unstructured interview; observation; gaming

• Conduct: The scenario description of information system usage should be obtained primarily through unstructured interviews of system users combined with direct observation of system operation.

Results of the previous phase, matching systems with the information support services they provide, should be in hand during development of the scenario of information system usage. This will help to insure that variations in system usage will be included in the scenario description. Situational descriptions can be used to supplement knowledge of procedures by using operational gaming techniques. Reactions to these situations can be more authentic when presented in an impromptu fashion. In-basket analysis can give a picture of actual data flows and can serve as the basis for observation of system users under controlled, simulated conditions.

Following is a checklist of questions to guide the interviewer and to direct attention to important observations during simulation of system usage.

(1) What is the nature of interaction with the system?

(a) What means of access or communication?
(b) Describe Forms of input and output?

(2) When to you use each system?

(a) How frequently?
(b) Under what conditions?
(c) What are the restrictions on use?

(3) How are basic functions performed?

(a) Describe procedures for creating, modifying and accessing files.
(b) Describe responsibilities for error correction and verification of data inputs.
(c) Describe efforts to interpret and analyze system outputs.

(4) What is the purpose of the system?

Contrast various views of purpose among functional users with the formally stated objectives and goals.

Differentiate the goals at various levels of management and activity.

- Result: This phase of the analysis should result in a written description of actual system usage in scenario form. It should include all significant variations of expected usage which provide different information support services. This scenario is contrasted with system documentation to produce a summary of variances between current and intended system function.

c. System Evaluation Measures and Criteria

• Purpose: To define quantitative measures and criteria useful for system evaluation. The criteria should indicate threshold levels of satisfactory system performance. Subjective opinions must be translated into tangible measures of effectiveness. Preferably, this step should involve only updating of measures identified during system design.

• Selection:

Characteristics

Planning	Normally relevant and advisable
Management	Relevant and necessary
Communication	Possibly relevant
Data Base	Relevant and desirable
Reference	Relevant and desirable
Monitor	Relevant and necessary
Scientific	Possibly relevant

Activity Levels -- Strategic, tactical, operational and execution

Methods -- Unstructured interview; Delphi; analysis and gaming based on scenario; accounting and performance records.

• Conduct: The evaluation team should start this program phase by reviewing system goals and proposed methods of measuring in order to assess these in light of the functions served and information support required. General goals must be refined to specific objectives which make clear what constitutes satisfactory system performance. Typically, this involves identifying critical parameters of the system and specifying the levels to be attained for satisfactory performance. This step is extremely difficult and time-consuming if objectives and measurement of progress were not articulated in the initial design.

A measure of effectiveness (MOE) is generally an operational factor which is expected to vary directly with information system(s) effects. Functional performance ratios are frequently good candidates for such measures. For example, a production control system might use the proportion of indirect to direct employees as an MOE. Of real interest is the percent or dollar value of improvement which can be attributed to the information system. In order to isolate system effects, it will be necessary to review historical data on operations under varied conditions and processing methods. Where possible, the factors analyzed should be also used for operational purposes in order to reduce bias in the statement of benefits derived from the system.

User opinions of the technical, economic and operational benefits expected from a system, developed earlier, are valuable inputs in the formulation of a MOE. In the absence of well defined measures, general concensus among users concerning an expected benefit should be emphasized in formulation of a MOE. Normally, careful delineation of an expected benefit will make evident a corresponding MOE. If a wide disparity of opinions exists among users concerning expected benefits, the Delphi technique may prove to be useful for reaching concensus. The Delphi technique may also prove useful in ordering and compacting an initial set of possible MOEs. Several members of such a set may correlate so highly that only one of the measures need be retained. Care must be taken to differentiate the desired benefits at various levels of management and/or activity.

In some cases, historical data can be used to perform a regression analysis in order to determine the contribution of various factors to system success. Often the operational parameters used to measure improved performance relate to

normally kept statistics. In many cases, the parameters can be expressed in terms of dollars by using accounting practice already established.

Structure is given to the interview through use of a predetermined list of general performance factors. The list includes factors most frequently significant in a variety of functions, and the user may choose to define additional ones of unique concern in a particular application. This set is useful in comparing views of a system from varied sources and in comparing different systems.

For each factor, the user is asked to rate his degree of concern in using the system over impact on operations, and actual or anticipated performance by the system. Ratings are subjectively weighted at one of five levels as follows:

Weight	Degree of Concern
4	Critical or major
3	Special attention necessary
2	Desirable, standard approaches adequate
1	Not considered
0	Insignificant

Weight	Actual or Anticipated Performance
4	Notably effective
3	Satisfactory; improvement possible
2	Effects not discernable
1	Annoying; improvement desirable
0	Detrimental; correction of serious flaws mandatory

Following is the list of general performance factors to be rated in Table III-1.

TABLE III-1

PERFORMANCE CONSIDERATIONS

	Concern Weight	Performance Weight
1. Gathering and recording data		
2. Accuracy and verification of input		
3. Editing and encoding of data		
4. Transaction flow characteristics and growth potential		
5. Mutual dependence of users and files		
6. File size and growth potential		
7. Retention and integrity of files		
8. Compatibility of data among systems		
9. Duplication of effort or records		
10. Response time		
11. Interaction or intervention during processing		
12. Accessibility and ease of use		
13. Byproduct use of data		
14. Format variability in output		
15. Reproducible results		
16. Graphics		
17. Output retention and distribution		
18. Communication among user locations		
19. Comparison among trials		
20. Statistical analyses		
21. Content retrieval		
22. Skill of user in programming		
23. Independence of hardware/software		
24. Control over operation of system		
25. Flexibility in changing parameters or procedures		
26. Manual effort reduction		
27. Training required		
28. Analysis of system activity		
29. Reliability and backup		
30. Schedule restrictions		

• Result: This phase of the analysis should provide a set of measures of effectiveness which reflect the true objectives of the system. Some effort should be made to minimize this set by eliminating redundant MOEs. A level of achievement should be established for each MOE which is the minimum required to achieve "satisfactory" system performance. Also, a compensatory objective function may be established to relate the various parameters.

A description of chosen MOE, methods for measurement and analysis, and factors influencing the choice of a MOE should be included in a formal report. This report should be reviewed and explicitly approved by management authorizing the evaluation study.

d. Computer System Performance

• Purpose: To assess the role of computer performance factors in influencing the effectiveness of the system. Each performance factor must be considered relative to its potential impact on operations. For this reason, the degree of operational concern over each factor must be assessed as well as actual computer system performance for each.

• Selection:

Characteristics

Planning	Sometimes relevant
Management	Sometimes relevant
Communication	Relevant and necessary
Data Base	Relevant and necessary
Reference	Often relevant
Monitor	Relevant and necessary
Scientific	Often relevant and advisable

Activity Levels -- Operational, execution

Methods -- Structured interview, analysis of system and department documentation.

• Conduct: At this phase, operational limitations or characteristics caused by the computer system are analyzed. Thus, the environment in which the information system must work is characterized and contrasted with expected or desired situations. This normally consists of reviewing and updating department and system documentation.

In addition to subjective estimation of performance factors, actual measurement of certain highly quantitative factors is often feasible at very little expense. In many cases, the system itself will have facilities for expediting its own performance measurement. Performance factors like response time, file size and growth, and reliability are exceptionally good candidates for this sort of treatment.

The particular items related to computer system performance which should be recorded are outlined in Appendix C. Emphasis should be on estimates and existing data related to use and operation of the information system.

• Result: A summary of computer performance findings which limit system effectiveness should be included in a formal report; perhaps the same report as discussed in the previous section, System Evaluation Measures and Criteria. This report should highlight the notably effective performance factors in the system as well as problem areas. System problems should be discussed in relation to their degrading effects on performance in operational areas. Suggested computer system changes and their anticipated benefits should also be reported. Details identified in this area should be used to update existing documentation about organization and computer system utilization. The impressions and feelings about the system will be verified later in the phase related to actual measurement of activity.

2. Audit Economics of the Information System

Using standard job and task definitions, the initial investment in the system is assessed and then reviewed in light of revisions implemented and planned. Both operating expenses of the system, including programming maintenance and user involvement time, and operating savings are audited. Where possible, the results are compared to prior operations or alternative methods. To the extent accounting procedures allow, resultant changes in performance are translated to variances in expense dollars.

a. Investment

• Purpose: To evaluate the fixed development cost of each system. This must include the initial investment as well as all subsequent costs incurred for refinements and additions to the system. It presumes that standard job and task definitions exist in the organization conducting the study.

• Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Relevant and necessary
Scientific	Relevant and necessary

Activity Levels -- Strategic, tactical, operational, execution

• Method -- Accounting and project management records

• Conduct: Records dating back to the initial stages of systems analysis and design should be collected for this phase of the analysis. Considering both data processing

and customer or user commitments, the initial investment in the system should be calculated, taking explicit account of the following aspects in the development of each system:

(1) Systems Analysis

Definition of system objectives; feasibility study; user requirements.

(2) Systems Design

Specifications for programs, procedures, file structures, input and output report content, algorithms and models; flow charts and decision tables; programming conventions and standards.

(3) Programs

Coding or acquisition of compute programs in operational status.

(4) Testing

Verification that software and hardware performs according to specifications and requirements.

(5) Conversion

Operational changeover of files and procedures.

(6) Documentation

User manuals, program descriptions.

(7) Hardware additions

New hardware necessary to support the system.

(8) Planning, orientation and education

Indoctrination of users and operators in effective system use.

(9) Overhead

Project management, administrative support and personnel services.

In some cases, it may be necessary to distribute these costs over several systems. For example, new hardware or a newly converted common file may serve several systems and overhead costs must be prorated among the systems.

Costs incurred in these areas subsequent to initial system development should also be obtained from accounting

records. Care must be taken, however, to account for the time value of money by discounting all costs back to a standard time period--generally the period during which the original system development activity was begun. The interest rate to be used for this cash discounting is a matter of corporate policy. Fixed system costs can then be spread over the entire expected life of the system, facilitating consideration of the original investment with operating costs and savings.

• Result: This phase of the analysis should yield a summary statement of all costs incurred in the investment in each system. By expressing these in terms of well-defined major tasks and jobs, it is possible to compare the effectiveness of development among systems and to plan more effectively for future development.

b. Operating expenses

• Purpose: To evaluate the recurring expenses associated with system operations. All expense levels should be measured for a standard accounting period.

• Selection:

Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Relevant and necessary
Scientific	Relevant and necessary

Activity Levels -- Strategic, tactical, operational, execution

• Method -- Accounting and functional activity records

• Conduct: Financial data and activity reports from

recent accounting periods should be collected for this phase of the analysis. Using standard job and task definitions, operating expenses for the period should be calculated taking explicit account of the following areas:

(1) Personnel

(a) Operations

Supervision, clerical, equipment operators

(b) Maintenance of system

Preventive and corrective hardware maintenance; corrective software maintenance; operating system improvement.

(c) User involvement

Time spent by user in preparing and editing inputs, collecting and interpreting outputs.

(2) Supplies

Forms, cards, tapes, paper, etc.

(3) Equipment

Hardware rental charges or amortized cost.

(4) Software

Cost of using software, generally based on utilization of scarce resources

(5) External services

Programming, consulting, communications, time sharing etc.

(6) Overhead

Ongoing costs for operations management, administrative support and personnel services.

The above expenses should be sampled in several recent accounting periods, noting variations due to environmental and system changes. Additionally, there may be variations due to seasonal factors in system usage which must be considered in the sampling plan. Care must be taken in this phase of the analysis to distinguish normal on-going costs from intermittent costs. Large intermittent costs which occur by chance in the accounting periods under study could invalidate the analysis if not distributed over time to give a fair

picture. Particular attention must be given to apportioning costs consistently among systems for items that are shared. For example, costs of running and maintaining an operating system must be rationally apportioned among systems for various time periods.

• Result: A report on actual expenses is the basis for estimating the financial worth and life of the system in question. The investment in the system, allocated over the system life earlier, can then be combined with operating expenses to form a total cost statement for each system. Further analysis of the costs involved in system operations can be a worthwhile venture, often revealing which areas offer the greatest potential for cost reductions.

c. Operating savings

• Purpose: To identify the improvements in cost of or benefits from system operation. The savings are expressed in terms of cost reduction for similar services or of improved services for a lesser increment of cost.

• Selection:

Characteristics

Planning	Not relevant
Management	Perhaps relevant
Communication	Relevant and necessary
Data Base	Relevant and desirable
Reference	Difficult to define
Monitor	Relevant and necessary
Scientific	Relevant and advisable

Activity levels -- Operational and execution, often tactical, rarely strategic.

Method -- Accounting and functional activity records.

• Conduct: Records may support direct comparison of

alternative ways to provide similar services or to compare performance before and after system changes. If accounting and controller offices have agreed upon the measures of effectiveness derived earlier, it should be possible to ascribe dollar value to changes in these functional parameters. This normally entails negotiation of the amount of savings or benefits which can be attributed to system improvements alone. For instance, a reduction in personnel turnover or of inventory level may be aided by better information service, but is normally also affected by other variables.

Again, standard definitions of tasks, jobs, or costs and consistent application of procedures is necessary for meaningful cost/savings comparison for a system. The effects of different systems cannot be compared unless substantial discipline is achieved in defining and recording operational data related to costs.

- Result: For those systems which afford assessment of savings, the return on investment in the system can be calculated for its estimated life. Decisions can be made about continuing operation, redesign, or replacement of the system.

3. Measure Information System Activity. In this phase, all tangible evaluation factors should be measured to assess actual versus expected performance. This would involve comparison of ratios related to expected resource use and benefit achievement over several time periods. Analysis of activity should include observations as well as statistics recorded by the system itself. Accuracy of input should be verified and related to earlier subjective views of confidence in output. Particular attention should be given to determining the sensitivity of system output to changes in input from either the function served or the environment of the system. Statistics should be analyzed on various aspects of system use and growth to verify both projections and subjective opinion. A single system must be placed in context with related systems and functions served. The growing trend to broaden perspective and to integrate more areas suggests that a system will normally impact others, either with demands and side effects or with added benefits recognized elsewhere. If so, the audit should include those credits or debits for the system being evaluated.

a. Accuracy and Control over Input

- Purpose: To assess accuracy of input data and effectiveness of controls over data gathering, transcription or encoding, transmission, and editing. A description of the linkages between data sources and reports or listings for various functions will also be developed. Included are counts of transaction or message activity and structure or format of the different types of input.

- Selection:

Characteristics

Planning	Relevant to consistent and representative samples over time
Management	Relevant, but may have trade-offs with timeliness and/or cost

Communication	Relevant and necessary
Data Base	Relevant and necessary for operational, possible tactical
Reference	Relevant; usually a problem of completeness
Monitor	Relevant and necessary
Scientific	Relevant and advisable

Activity Levels -- Tactical, operational, and execution

Methods -- Work sampling, procedure analysis, matrix or graphical description; hardware and/or software monitors.

• Conduct: Work measurement methods can be used to determine the amount of effort expended by users in preparing inputs, verifying entries, and making corrections. Work sampling procedures can be used extensively to determine the volume and nature of input, including proportion by type and frequency of errors. Traditional statistical methods can be used to determine factors such as required sample size or confidence limits. Integrated Procedures Control (IPC), outlined by Richardson in reference 38 of chapter II, provides methods for systematic collection of pertinent facts regarding inputs, outputs, files and transactions involving these. Use of IPC facilitates subsequent analysis of data forms by standardizing data collection procedures and allowing summaries of facts regarding data forms to be prepared in a variety of ways.

Input/output charts provide a visual portrayal of system inputs and their relationships to reports or input to other systems. Expansions of this concept show the relationships between data elements at source, in messages, in files, and in outputs while indicating frequency of use and both the size and means of transmission. Matrix models depicting data paths from input sources to output functions can be used to study the flow of data through the system.

This analysis may reveal alternative paths which can be used to audit or validate transactions within the system relative to inputs. Alternatively, analysis may reveal redundant processing, in which case certain input sources may be eliminated. The relationships among activities and data flow may also be shown by graphic methods. (See Table II-1.)

• Result: The volumes and descriptions of all types of inputs are recorded and the nature and frequency of errors, including omitted and faulty transactions, are indicated. This can then serve as the basis for a data flow analysis which shows the effectiveness of gathering and controlling input and the relationship to output. This phase results in a formal representation of data flows and estimates of the accuracy, cost, and timeliness of data available to various functions or other systems.

b. Performance Versus Expected Benefits

• Purpose: To determine the accomplishment of the system with regard to the criteria and measures of effectiveness established earlier. The effects of each system are assessed to develop both qualitative and quantitative estimates of the level of attainment of each M.O.E.

• Selection:

Characteristics

Planning	Relevant, but effects may be ill-defined
Management	Relevant and necessary
Communication	Relevant and desirable
Data Base	Relevant and desirable
Reference	Relevant and desirable
Monitor	Relevant and necessary
Scientific	Relevant and desirable

Activity Levels -- Strategic, tactical, operational, execution

Methods -- Observation; accounting and operational records; structured interview

• Conduct: The very nature of each MOE will limit the selection of measuring methods and the evaluation team will need to carefully weigh the cost of measuring to determine appropriate methods. Least cost is associated with results generated as by-products of normal operation. Records already kept by the organization often contain the information needed for MOE calculations. In many instances, these are records generated and maintained by the information system itself. Again, the use of statistical analysis allows control over the accuracy and precision of the measurement process.

Occasionally, the evaluation team will need to observe operations first-hand in order to evaluate measures of effectiveness. This can be a time-consuming and costly project. If such costs are high, and no alternative means of measurement are feasible, then the value of the MOE should be reconsidered. A related parameter may be found which is more amenable to measurement. Hardware and software monitoring and measuring devices may be useful at this stage for systems geared to the operational control and functional execution activity levels.

Structured interviews may be used to rate the merit of the system in relation to specific functional parameters or objectives. This approach is necessitated when objectives or MOEs are ill-defined, or not quantifiable, and when measurement is excessively expensive, difficult or erratic.

• Result: The level of attainment reached for each expected benefit should be compared over different time periods for trends and against criteria for achievement success. The report should also describe any special conditions or extenuating circumstances which make the

measurement results suspect, including accuracy or precision of measurements and subjective bias. Finally, the report should contain a summary view of system success relative to critical parameters and/or a net judgment based on weighted qualitative and quantitative factors.

c. Actual Versus Expected Resource Requirements

Purpose: To compare actual resource requirements with those expected and defined during planning and development. Much of this analysis follows from economic analysis of investment and operating costs in relation to those budgeted or advertised. In addition to the cost items mentioned earlier, special attention must be given to computer capacity or time utilized and to personnel skill levels needed. File storage, software, communications, and personnel effort are frequent offenders at demanding more capability than expected.

Selection Characteristics

Planning	Relevant and necessary
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary
Reference	Relevant and necessary
Monitor	Relevant and necessary
Scientific	Relevant and necessary

Activity Levels -- Strategic, tactical, operational and execution

Methods -- Observation; project management, operational and accounting records; feasibility studies, project authorizations and budgets; hardware and software monitors.

• Conduct: Ratios should be developed for all kinds of resources expended during both the development operation of the system. For system development, typical ratios would involve resource requirements for manpower and capital. For manpower requirements it is useful to consider resources at various skill levels such as clerical, programmer, and systems analyst for various specific tasks. The ratios of actual usage to planned usage of these personnel resources will help to facilitate planning of personnel requirements for future systems work if the tasks are sufficiently described and standardized.

Resource requirement ratios for the operation of a system should not be limited to those applied to run the system, such as manpower and supplies. Resources internal to the system should also be considered relative to the hardware and software capability absorbed by each system. Examples are capacity utilization of mass storage, CPU time and peripheral or I/O devices.

To measure the current utilization of computer resources, a variety of hardware and software monitoring tools are available. These tools are especially useful for measurement of time or capacity. The system itself will often provide outputs which indicate the current level of utilization of such resources.

Information regarding actual utilization of personnel, consumables and capital can be found in project management, operational and accounting records. Where these are not available, it may be cost justified to observe system performance to measure critical resource utilization.

Comparison is impossible unless target or budgeted requirements are documented by management and changes in needs are carefully included. These records must be specific about well-defined tasks and activity to be meaningful.

• **Result: This phase of the procedure produces a documented comparison of planned resource requirements with actual resource utilization. These comparisons are normally expressed in terms of ratios which indicate the relative level of performance. These statistics should be gathered for different time periods to assess trends. Care should be taken in interpreting needs during transitional periods, such as installation.**

For ratios of significant resources which indicate unusual variance from norms, the team should report steps taken to find reasons for the discrepancy. Frequently, changes in original objectives or specifications have not been factored into the expected resource requirements.

d. Sensitivity of System Output

• Purpose: To determine the effect of variations in data input or assumed environment on the success of the system. The sensitivity analysis determines the likely magnitude and character of changes in system output and their subsequent impact on user behavior. These changes may result from normal fluctuation of input values, from input error, from suppression or filtering of input, from changes in source, from time period inconsistencies, from system alteration, and from changes in the functional or system environment.

Depending on the expectation for variation in these areas, the ability of the system to adapt to change may be a highly desirable or even necessary asset. On the other hand, wide variations of input may have no significant effect on user performance or selection of alternatives. The latter suggests that the system may have little value for anything other than execution and some operational activities.

- **Selection:**

  Characteristics

Planning	**Relevant and advisable**
Management	**Relevant and necessary**
Communication	**Rarely relevant**
Data Base	**Relevant and advisable**
Reference	**Relevant and advisable**
Monitor	**Relevant and usually necessary**
Scientific	**Relevant and necessary**

  Activity Levels -- Strategic, tactical and often operational

  Methods -- Gaming; simulation; graphical analysis; work sampling

- Conduct: Problems associated with this phase of the analysis stem from the fact that measurement is not always possible if the system is currently constrained by active use. Thus, in addition to usual measurement problems, the evaluation team also faces the problem of hypothesizing and imposing likely changes to the environment or the input stream. Earlier phases of the analysis (especially A1) should provide a good background in the general types of changes to anticipate, but interpretation of these in terms of the system may be difficult. Gaming techniques may be useful in determining the user's modified system needs when changes are hypothesized.

In some cases, it will be possible to use the system under changed conditions. Work sampling can then be used to study the resulting effects on system outputs and/or user behavior. Systems based on certain specific mathematical models provide the potential to gather sensitivity information as a direct consequence of applying the algorithm. Relationships among inputs, outputs and probable alternatives of action can also be depicted by graphical methods to show the possible changes in user behavior.

Probably the most widely useful technique for sensitivity analyses is simulation. Actual experimentation with the system may be infeasible because of ongoing operations or because of economic considerations. Simulation facilitates sensitivity testing under a wide variety of conditions and input factors. The main problem with simulation is ensuring that all critical factors of the real system are included in a valid simulation model. This approach allows controlled experimentation to assess the statistical significance of changes in the parameters and factors comprising the simulation model.

- Result: Conclusions of the sensitivity analysis should be included in a formal report. This report should describe the types of changes which the system can accommodate and the boundaries within which these changes cause no major alteration of output significance. Also, expected changes which will alter substantially or deteriorate either system performance or user function should be indicated. If little change is possible or system output is impervious to change, the value and cost of the system should be made commensurate with the highly restricted potential benefits.

e. Impact on Other Systems/Functions

- Purpose: To measure the effect that this system exerts on related systems and functions. The net worth of the system may be impossible to measure if considered as an isolated entity. In such cases, this phase of the analysis assumes a great deal of importance.

- Selection:

Characteristics

Planning	Desirable; usually relevant
Management	Relevant and necessary
Communication	Relevant and necessary
Data Base	Relevant and necessary

Reference	Relevant and necessary
Monitor	Rarely relevant
Scientific	Rarely relevant

Activity Levels -- Tactical and operational; strategic in its relation as a by-product of other systems; execution in its relation as a source of data to others.

Methods -- Accounting records; consensus; simulation

- Conduct: This phase is particularly important in situations where several systems serve the same functional activity or where new systems are introduced. Assuming that the effect on key performance indicators can be measured, it will be difficult to determine the exact cause of any change. It may be possible to ascertain the credit due to a system by accounting methods or pre-determined criteria. In any event, it is normally necessary to solicit subjective opinions about the relative contribution of system or environmental changes to differences in functional performance. The consensus may be used as the basis of an accounting allocation or of a qualitative judgment of system worth. If sophisticated models of the organization exist, it may be possible to assess the cause and effect relationships by a series of experiments. The latter approach is normally too costly for such an imprecise estimate.

- Result: The benefits and costs assigned to a given system must be modified in light of its impact on other proximate systems or its contribution to functions relative to other systems. This phase reports the proportion of direct benefits and the absolute value of any indirect benefits which can be legitimately (with management concurrence) claimed by the system. In addition, any costs

incurred by other systems or functional overhead which can be attributed to the system under study are identified as supplements to costs considered earlier in the evaluation study.

IV. Summary

This manual is a working document to assist in evaluating a variety of information processing activities. A generalized procedure is outlined to assess the capability of an information system to meet functional, user-oriented requirements. The authors propose a composite overview which will be the basis of a systematic approach to information system evaluation. Stress is placed upon identification of tangible benefits and measures of effectiveness. Refinement and standardization of the approach are anticipated on the basis of experience in applying its phases to systems operating under differing circumstances.

APPENDIX A

Glossary

Activity levels -- Categories of functional activity and tasks which involve varied degrees of decision-making and operational involvement. See Table I-1.

Characteristics, Processing -- Categories of data processing activity designated by fundamental nature of handling, storage, operation, and dissemination within a system. See Table I-2.

Decision System -- The set of decision rules which are integral to a functional activity in an organization. Information must be provided to employ the rules and the decision system specifies the supporting information system(s).

Delphi Technique -- A systematic, iterative means of gathering and aggregating subjective opinions about uncertain or speculative situations from a group of knowledgeable persons. Avoids bias normally associated with face to face encounters among participants.

Functional Activity -- Activity directly related to the functions which must be performed in order to achieve organizational objectives or mission.

Gaming -- An exercise in which humans play roles in a contrived typical or actual environment under controlled conditions. The players are confronted with competitive or conflict situations which include chance results from performed tasks. The environment and situations are described in scenarios. Purposes of evaluation emphasize operational gaming rather than training, diagnosis, experimentation, or entertainment.

In-basket Analysis -- A gaming approach which involves reaction of an individual to a series of planned conflict situations represented by documents delivered to him. A scenario establishes the role of the individual, background facts, and the operational circumstances for which the documents are typical.

Alternatively, the analysis may refer to sampling of the documents, and their sources and destinations, which are encountered by an individual. This provides a description of activity and information flows of the individual. It may be used as representative gaming material for his circumstance and position.

Information service or support -- Assistance required or provided by a group which involves transfer of information. This may utilize a number of sources or systems to provide the service or support.

Information system -- A set of interrelated rules and procedures for processing data into information in order to get or control action.

Measure of effectiveness (MOE) -- Parameter or variable which indicates the level of performance in an essential aspect of a system. Usually expressed in tangible terms related directly to functional objectives and effects.

Methods of analysis -- Variety of techniques which can be utilized to study characteristics and activity of a system in either quantitative or qualitative terms. See Table II-1.

Performance measurement -- Analysis of computer system performance; normally in terms of speed of operations, computer throughput, capacity utilization, response time and other factors related to the computer itself.

Requirements -- Functional description of a system(s) expressed in terms of the needs of the user or customer of the system and its output. (See Appendix B.)

Scenario -- Description of the environment, tasks, and roles associated with an operational situation. Normally shows the setting and scripts of behavior related to actual use or operation of functional activities or information systems. Since it is based upon current experience, it can be contrasted with intended

procedures or reactions. Often includes instructions for gaming participants under varied conditions and for those who conduct or assess the performances.

Simulation -- Process of generating representative numerical results by using a model of the actual process or activity. Normally used when uncertainty or complex interrelationships make analytical solutions infeasible. Distinguished from gaming which uses a simulated (modelled) environment to develop human behavioral reactions and output.

APPENDIX B

System Conceptualization and Definition

1. Preliminary Phases

a. Problem Investigation. Customer exploration of ideas about new or revised applications or systems. This includes initial formulation of project requests, evaluation of available resources to solve a customer problem, and development of proposed solutions to customer problems. This may replace or be included in feasibility studies for small or well-defined problems. Results in a formal Problem Statement and leads toward economic analysis and Justification of a proposed approach to problem solution.

b. Feasibility Study. A study for management analysis, prepared primarily by systems analysts, to assess the technical, operational and economic issues related to achieving a stated customer objective. For simpler applications, economic analysis for Project Justification in the Problem Investigation phase may be adequate. Most systems will require a formal study and report, consisting of the following general content:

- Objective.
- Preliminary statement of requirements and design features.
- Alternative approaches.
- Recommended solution.
- Justification, priority and benefit analysis.
- Scheme for implementation.
- Estimates of resources.
  - Personnel
  - Equipment
  - Financial
- Organizational effects and support.
- Task force or project team requirements and possible composition.
- Preliminary project plan, including overall networks and major task definition.

2. User Requirements. A functional description of the system prepared by customer representatives and system analysts subsequent to feasibility study and development of priority assignment.

The User Requirements should emphasize a new system and its characteristics rather than describe an existing one. If substantial differences with the Feasibility Study appear, it may be necessary to reevaluate the economic, operational and technical justification.

This phase is dedicated to system analysis and to user orientation and understanding. Facts must be collected about the current and proposed system through:

a. User interview.

b. Operations observation and activity analysis.

c. Source data identification.

d. Organization review and analysis.

Correlations with data in other systems and identification of critical outputs must be accomplished. The processing relationships must be established and the possible impact of the new system on affected organizational units must be indicated. The Requirements should be documented into a formal report, subject to customer approval, with the following content:

- Mission and/or problem statement.
- System Objectives.
  - Management agreement with scope of system
  - Establish criteria for success
  - Determine:
    a) primary functional and/or organizational units served by the system
    b) secondary functional and/or organizational units served by the system
    c) inter-intra organizational operation relationships
  - Establish a glossary of terms pertinent to the system.
- Output and Reporting Definition.

- Determine management reports required by the business, independent of cost of supplying such reports.
- Establish a rough cost/value relationship of each management report.
- Define terms and fields for each report.
- Identify report quantity, distribution, and schedule constraints.
- Ascertain security and/or proprietary aspects of each report.
- Identify influences on report requirements:
    a) Government regulations
    b) Company auditors
    c) Public accountants and auditors
    d) Customer requirements
- Evaluate possibilities and value of improved customer service.

• Input Definition.

- Determine input data requirements based on analysis of output.
- Determine files in which such data already exist (these files may be "common" to more than one system).
- Establish sources of data that may have to be gathered from new forms or procedures.
- Outline data preparation instructions.
- Study volumes:
    a) Normal
    b) Peak
    c) Frequency of peaks
    d) Expansion allowance

• File Definition

- Define content and purpose.
- Estimate size, form and rate of expansion.
- Describe record types and storage media.
- Define maintenance, updating, access activity.
- Outline procedures to afford and validate access.
- Define file retention constraints.

a) Legal restrictions

b) Functional requirements, e.g., closed charge numbers, inactive name and address files, etc.

- Controls and Tests.
  - Indicate edits for data validity and reasonableness.
  - Specify disposition of data rejected by edits.
  - Establish requirements for control totals, hash totals, record counts, programmer or operator access restrictions, checkpoints or restarts, etc.
  - Determine backup and recovery requirements in case of file loss or damage, or catastrophic error.
  - Indicate test requirements, quality assurance needs and sensitivity to system performance.
- Schedule constraints
  - Describe operating cycle and turnaround characteristics.
  - Prescribe capability and priority commitments.
  - Analyze fluctuations and cycles of activity.
  - Effect of schedule delays on system and related systems.
  - Define requirements for the system to "carry-on" on a manual basis if computer is down for a prolonged period.
- Cost Analysis and Resource Constraints
- Proposed Project Plan

APPENDIX C

Computer System Factors

A. Organizational Environment

1. Fiscal operations procedures and control of the computing service department.

2. Personnel qualifications and organizational structure

3. Processing standards, controls and security of program and data files

B. Application Description

1. Dominant Operations

Identify the nature and extent of each:

a. I/O, user and system communication
b. Editing, reformating, error checking
c. Computation
d. File create, update, restructure

2. Storage

a. File name or category
b. Contents -- programs, data, queries, purpose
c. Medium
d. File organization -- access requirements, key fields
e. File size -- current or expected, growth allowance
f. Record structure -- fixed, variable length, codification

3. Input

a. Input message name or category
b. Data type -- Digital, analog, alphanumeric, text
c. Content, purpose, descriptive
d. Format -- rigid, free, special requirements, restrictions
e. Entry mode

(1) Transcribed centrally
--keyboard
--optical scan
--media conversion

(2) Transcribed at work site
--portable keyboard
-- paper tape punch
--magnetic tape recorders

(3) Direct entry from remote work site
--analog - Digital

--graphical display with light pen (etc.)
--OCR
--interactive keyboard

f. Transaction frequency and volume

(1) Intermittent Single, intermittent Bursts, Continuous
(2) Normal entry rate current
(3) Peaks entry rate current
(4) Peaks entry rate maximum growth

For (2), (3), and (4), estimate mean, range

4. Output

a. Output message name or category
b. Data media -- hard copy, graphical, voice, machine
c. Contents, purpose, description
d. Format requirements
e. Reporting mode

Scheduled
By exception
Background (as time available)
Articipated inquiries
Spontaneous inquiries
Browsing or tutorial

What input?

f. Output frequency and volume

(1) Normal rate current
(2) Peak rate, current
(3) Peak rate, maximum growth
Estimate mean, range

C. Computing System Attributes

1. Which of the following system attributes are existing problems for your application?

2. Which are apt to become as problems with anticipated growth?

3. What additions or changes to the system would help alleviate the problem?

Program Development Cycle

Hardware independence - ability to develop and execute programs with varying hardware configurations

Development of new programs (adequacy of programming languages and debug tools)

Standard Library routines

Modularity of programs

Modification and maintenance of programs

Adaptation and parameterization of programs

Preparation and generation of test cases and materials

Verification of test results

Program Operations Cycle

Impact on existing applications

Turnaround time

Accuracy and verification

Frequency of use

Schedule of execution

Transfer of data among systems

Sensitivity to job mix

Common processing standards

Compatibility of programs, data, vocabulary

Reliability and backup of equipment

Accommodates sources

Data Base Upkeep Cycle

Data Preparation Activity

Modularity of files

Ease of updating files

Common recording standards

D. Computing Environment

1. Hardware Description

a. Processing units (CPU)

(1) How many processing units? Do they perform specialized functions? Identify the nature of each.

(2) Support for fixed point arithmetic - word size(s)
floating point arithmetic - word size(s)
Decimal arithmetic - word size(s)

(3) Describe special hardware provisions for
--interrupt handling
--program relocation and addressing
--detecting equipment malfunctions

--modularity and configuration of hardware components
--protection of data integrity
--storage access
--emulation, microprogramming
--multiprocessing

b. Storage - For each type, identify manufacturer, name of unit, how many you have, how many can be supported, and storage capacity per unit (in bits). Describe any special features.

(1) Core storage

High speed main storage
Slower speed mass storage

(2) Sequential access

Magnetic tape

(3) Direct access

Disk
Drum
Magnetic cards

c. I/O Communication

For each type, identify manufacturer, name of unit, how many can be supported. Describe any special features.

(1) Unit record equipment

Card Reader/Punch
Paper Tape Reader/Punch
Magnetic character reader
Line printer

(2) Interactive Communication

Printer/Keyboard - TTY or I/O Typewriter
Graphics - keyboard and CRT
Voice input and/or response
Special purpose console

(3) Intersystem Communication

Phone lines
TTY
Special purpose

(4) Others

Plotters
Optical Scanners

d. Configuration of a, b, and c

2. Support Software Description

For each category of system support, list which services are available under the system, describe the service briefly, and indicate whether you have it. Following each category below are some key features to consider in the description.

a. Task Execution Support Services

Multiprogrammed? Fixed or variable number of tasks? Maximum number of tasks? Multiprocessing?

Local batch, remote batch, interactive modes.

b. Programming Languages

What languages?
Available in what modes; local or remote batch, interactive?
Compile, Assemble, Interpret, Generate

c. Data Management Methods

Describe in terms of file organization requirements.

d. Debug and Test Facilities

Program tracing, dumps
Test data preparation

e. Program Library Facilities

Creation and update capabilities
Nature and Size of Library

f. Support Programs

Utility, data conversion, test generators, debugging aids, edit features